MILLER CONSTRUCTION, INC.
P.O. BOX 86 ASCUTNEY BLVD WINDSOR, VERMONT 05089-0086
TELEPHONE (802) 674-5525 / FAX (802) 674-5245

TRANSMITTAL

TO:	DATE	PROJECT NO.
Jennifer Fitch, PE Project Manager Vermont Agency of Transportation	8/18/2014	Brookfield BRF FLBR (2)

XX WE ENCLOSE THE FOLLOWING: ______ UNDER SEPARATE COVER WE ARE SENDING THE FOLLOWING

COPIES	NUMBER	DESCRIPTION	CODE
1		Dynamic Pile Test Results	H

CODE:

A FOR INITIAL APPROVAL
B FOR FINAL APPROVAL
C APPROVED AS NOTED-RESUBMISSION REQUIRED
D APPROVED AS NOTED-RESUBMISSION NOT REQUIRED
E DISAPPROVED-RESUBMIT
F QUOTATION REQUESTED
G APPROVED
H FOR APPROVAL
I AS REQUESTED OR REQUIRED
J FOR USE IN ERECTION
K LETTER FOLLOWS
L FOR FIELD CHECK
M FOR YOUR USE

BY: Paul [signature]

GEOSCIENCES TESTING AND RESEARCH, INC.

55 Middlesex Street, Suite 225, N. Chelmsford, MA 01863
Ph: (978)251-9395, Fx: (978)251-9396

August 8, 2014 GTR Project # 14.125

Mr. Paul Holloway
Miller Construction, Inc.
3103 US 5 South
Windsor, VT

RE: Dynamic Pile Testing Report
Brookfield BRF FLBR (2) Bridge Replacement
Brookfield, Vermont

Dear Paul:

At your request, we have performed dynamic pile testing at the above-referenced site on August 4 and 6, 2014. The dynamic testing was requested in order to evaluate pile capacity, driving stresses, and hammer performance during test pile installation. Testing was conducted using the Pile Driving Analyzer™ (PDA) Model 586 PAK, which records, digitizes, and processes the force and acceleration signals for use in the Case Method and CAPWAP analyses. The dynamic testing was carried out in general accordance with ASTM D4945, “Standard Test Method for High Strain Dynamic Testing of Piles” and the project specifications.

Field Details

Soil Details

The subsurface conditions at the site based on boring B-3 indicate there is approximately 10 feet of loose, granular fill that extends to approximately the bottom of Abutment elevation. The granular fill primarily contains fine to coarse sand with various amounts of gravel, inorganic silt and trace organic fibers. Underlying the fill is a 10 foot thick layer of medium dense silty sand and gravel. Very dense glacial till was encountered underlying the silty sand at approximately 20 feet below ground surface. The glacial till consists of fine to medium sand and silt with various amounts of gravel, cobbles and boulders. The till transitions to very dense sandy silt at around 45 feet below grade to the bottom of the boring. The boring was terminated within the sandy silt glacial till layer at 100 feet below grade with no refusal encountered. Groundwater was encountered approximately 1 to 2 feet below grade at the time of borings. Refer to the boring logs and/or the geotechnical report for additional details regarding the subsurface conditions.

Pile Details

Steel H piles (HP12x74) were driven for the support of the abutment. The required nominal resistance is 135 kips. The cross-sectional area of the H-piles is 21.8 square inches. The piles are specified to be Grade 50 steel (yield strength of 50 ksi). The AASHTO recommended allowable compressive and tensile driving stresses are 45 ksi based on 90% of the yield strength (50 ksi). One of the test piles was driven on a 3H:12V batter.

Driving System

A Delmag D16-32 single acting diesel hammer, with a maximum rated energy of 39.2 kip-ft (ram weight of 3.5 kips and equivalent stroke of 11.15 feet), was used to drive the piles.

Instrumentation

The instrumentation consists of two strain gages and two accelerometer transducers attached a minimum 3 feet below the top of the piles. One strain gage and one accelerometer were placed on opposite sides of the pile to minimize the effects of uneven impact and pile bending. This instrumentation provides information about driving stresses (compressive and tensile), hammer performance (transferred energy), and pile bearing capacity.

The PDA is a computer fitted with a data acquisition and signal conditioning system. During driving, the strain and acceleration signals are recorded and processed for each hammer blow. The strain signal is converted to a force record and the acceleration signal is converted to a velocity record. The PDA saves selected hammer blows containing this information to disk and determines the compressive stresses, displacement, and energy at the point of measurement (pile top). In addition, the pile bearing capacity can be estimated in the field using the Case Method. This information can be viewed on the computer screen during driving. Selected blows can be further processed to predict the static pile capacity using the CAPWAP analysis. Refer to Appendix A for literature on the dynamic testing the Case Method and CAPWAP.

Results

General

The results of the dynamic testing are summarized in Table 1, which include the driven depth, blow count, stroke, maximum transferred energy, maximum pile top displacement, and maximum compressive stress at the gage location and maximum compressive stress at the pile tip. The blow count was recorded by others. The transferred energy, stroke, maximum pile top displacement, and maximum pile top compressive stress are determined by the PDA at the gage locations. The maximum compressive stress at the pile tip is estimated by the PDA.

Also included in Table 1 is the pile bearing capacity as determined by the Case Method in the field and CAPWAP analysis in the office. Three separate PDA plots of various parameters (maximum transferred energy and stroke - left plot, RMX Case Method capacity with Jc=0.5 and Jc=0.7 - middle plot, and maximum measured compressive stress at the pile top and max estimated compressive stress at the pile tip - right plot) are presented for the test piles in Appendix B. Appendix B also contains the above data, and additional data, in tabular form.

In Table 1, the Case Method capacity represents an average over the blows indicated for end of driving (EOD) or the beginning of restrike (BOR). CAPWAP analyses were performed on a selected blow from EOD data. Appendix C contains the full results of the CAPWAP analysis and Table 2 summarizes the CAPWAP results.

Field Observations and Hammer Performance

The test piles were installed to a depth of approximately 18 to 25.5 feet below ground surface, at which point the dynamic testing instrumentation gages were attached to the test pile. The pile was then driven with the APE D16-32 hammer to a penetration of around 19.5 and 27 feet below ground surface with blow counts ranging from 4 to 8 blows per inch (bpi). The hammer was operated at setting #3, corresponding to a typical stroke of around 6 feet and an average transferred energy of around 7 to 10 kip-ft. Restrike testing to assess time dependent changes in pile capacity was performed approximately 48 hours after EOD. The hammer was operated at setting #3 corresponding to a typical stroke of around 6 to 7 feet with transferred energy of around 10 to 11 kip-ft at BOR.

Pile Integrity and Stresses

The maximum compressive and tensile driving stresses were below the allowable limit (45 ksi) throughout testing. The pile cap should be positioned directly over the pile axial center of gravity to maintain good hammer alignment during driving. This minimizes bending stresses and keeps local stress concentrations to a minimum. There were no signs of damage or significant misalignment between the piles and hammer during testing.

Pile Bearing Capacity

The Case Method field capacity (using the RX7 relationship) ranged from 250 to 270 kips during EOD. The Case Method field capacity ranged from 260 to 280 kips during BOR. The CAPWAP capacity on a selected EOD blows ranged between 235 to 240 kips. Table 2 presents the results of the CAPWAP analyses in more detail. The total capacity, frictional capacity, end bearing capacity, and percentage of end bearing are included. The quake and damping soil parameters as determined from the CAPWAP analyses are also presented in Table 2.

Conclusions

The presented data from the dynamic measurements and their analyses leads to the following findings and conclusions.

1. A CAPWAP capacity of 235 kips was obtained for pile #1 in Abutment #1 (Batter Pile) at EOD based on an average blow count of 7 bpi. The APE D16-32 hammer was operated at setting #3 (6 feet stroke and an average transferred energy of 7 kip-ft) at EOD.

2. A CAPWAP capacity of 240 kips was obtained for pile #2 in Abutment #1 (Plumb Pile) at EOD based on an average blow count of 4 bpi. The APE D16-32 hammer was operated at setting #3 (6 feet stroke and an average transferred energy of 10 kip-ft) at EOD.

3. Based on the CAPWAP analyses, around 75 to 85% of the pile capacity was developed in end bearing.

4. The maximum compressive and tensile driving stresses were below the allowable limit during testing.

5. For the Plumb Abutment piles; we recommend a minimum driving criterion of 4 blows per inch for six inches with the hammer operating at setting #3 at EOD. The stroke should be at least 5.5 to 6.5 feet during EOD.

6. For the Batter Abutment piles; we recommend a minimum driving criterion of 6 blows per inch for six inches with the hammer operating at setting #3 at EOD. The stroke should be at least 5.5 to 6.5 feet during EOD.

7. If the piles “take up” quickly we recommend using a refusal criterion of 10 blows per ½.

Static pile capacity evaluations determined from dynamic testing provide an estimate of the axial pile bearing capacity at the time of testing. At very high blow counts (low pile set), the Case Method and CAPWAP analyses tend to predict lower capacities, since not all of the soil resistance may be fully mobilized, particularly at the pile toe. Other factors not considered in this analysis are bending, downdrag, lateral and uplift requirements, cyclic loading, effective stress changes (e.g. due to changes in the water table, excavations, and/or fills), settlement, and pile group effects. The foundation designer should evaluate if any of these issues are applicable to the pile design.

This report has been prepared in accordance with generally accepted geotechnical engineering principles with specific application to this project. Our conclusions are based on applicable standards of practice, including any information reported to and/or prepared for us. No other warranty, expressed or implied, is made. If you have any questions regarding this report, please do not hesitate to contact us.

Sincerely,
Geosciences Testing and Research, Inc.

Curtis A. George
Project Engineer

Les R. Chernauskas, P.E
Principal

Attachments: Tables 1 and 2, Appendices A through C

TABLES

TABLE 1
SUMMARY OF DYNAMIC TESTING
PROPOSED BRIDGE REPLACEMENT BRF FLBR (2)
BROOKFIELD, VERMONT
HP12x74 H-PILES OPEN-ENDED DIESEL HAMMER DELMAG D16-32

Test Pile	Date	Time of[1] Driving	Driven[2] Depth (feet)	Observed Blow Count (blows/inch)	Blow Number(s)	Stroke[3] (feet)	Maximum[3] Transferred Energy (kip-ft)	Maximum[3] Displacement (inches)	Maximum[3] Comp. Stress Pile Top (ksi)	Maximum[4] Comp. Stress Pile Tip (ksi)	Case[5] Method Capacity (kips)	CAPWAP Capacity (kips)
Abut 1 #1 Batter	8/4/2014	EOD	~26.2	7,10,11,11,8,11,10	3-63	5.3	4.8	0.29	17.0	12.5	228	-
			~26.8	7,7,7,8,8,6	66-106	6.2	6.9	0.38	20.4	13.2	252	235
	8/6/2014	BOR	~27	~ 4 bpi	1-33	7.1	11.0	0.46	24.2	14.0	283	-
Abut 1 #2 Plumb	8/4/2014	EOD	~19.5	4,6,4,3,3,4	21-46	6.1	9.6	0.52	23.2	12.1	263	240
	8/6/2014	BOR	~20.1	6,3,4,4,4,4	1-31	6.1	9.6	0.45	23.2	13.2	259	-

Notes:

1. Indicates that the data was obtained during driving or during the end of driving (EOD) or the begining of restrike (BOR).
2. Depth is referenced from grade next to the pile.
3. The stroke, maximum transferred energy, maximum pile top displacement, and maximum pile top compressive stress are determined by the PDA at the gage locations. These values represent an average over the blow(s) indicated.
4. The maximum compressive stress at the pile tip is estimated by the PDA. These values represent an average over the blow(s) indicated.
5. The Case Method capacity was determined using the RMX method and a JC value of 0.7. These values represent an average over the blow(s) indicated.

TABLE 2
SUMMARY OF CAPWAP RESULTS
PROPOSED BRIDGE REPLACEMENT BRF FLBR (2)
BROOKFIELD, VERMONT
HP12x74 H-PILES OPEN-ENDED DIESEL HAMMER DELMAG D16-32

Test Pile	Time of Driving	Blow Number				Percent End Bearing	Quake		Damping	
			Side	Tip	Total		Side (inch)	Tip (inch)	Side (sec/ft)	Tip (sec/ft)
Abut 1 Pile #1 Batter	EOD	94	60	175	235	74%	0.10	0.37	0.10	0.12
Abut 1 Pile #2 Plumb	EOD	33	35	205	240	85%	0.10	0.45	0.12	0.05

APPENDIX A
DYNAMIC TESTING LITERATURE

HIGH STRAIN DYNAMIC PILE TESTING

Introduction

Dynamic pile testing (a.k.a. High Strain Dynamic Pile Testing - HSDPT) is commonly employed for evaluating the capacity of driven piles. It is also provides information about hammer performance and pile integrity/stresses. Dynamic testing is carried out in accordance with ASTM D4945, "Standard Test Method for High Strain Dynamic Testing of Piles". Dynamic pile testing involves using strain gages and accelerometers to record an impact wave and its reflections generated by a piling hammer. Both driven piles and drilled foundations can be tested (provided that an impact hammer is used to create the high strain wave for the drilled foundations).

Procedure

Dynamic pile testing was performed using a Pile Driving Analyzer (PDA®), such as the PAK®, PAL®, or PAX® systems, manufactured by Pile Dynamics, Inc. (PDI) of Cleveland, Ohio. These systems are computers fitted with data acquisition and signal conditioning components. The instrumentation consists of two strain gages and two accelerometer transducers attached a minimum of 1.5 pile diameters below the pile top. During impact, the strain and acceleration signals are recorded and processed for each hammer blow. The strain signal is converted to a force record and the acceleration signal is converted to a velocity record. The PDA® saves selected hammer blows containing this information to disk and determines the transferred energy, compressive/tensile stresses, displacement, pile integrity, and the estimated pile bearing capacity using the Case Method. This information can be viewed on the computer screen during driving. A screen shot of data collection in the PDA® Windows (PDA-W®) Program is provided in Figure 1. Selected blows can be further processed to predict the static pile capacity using signal matching programs.

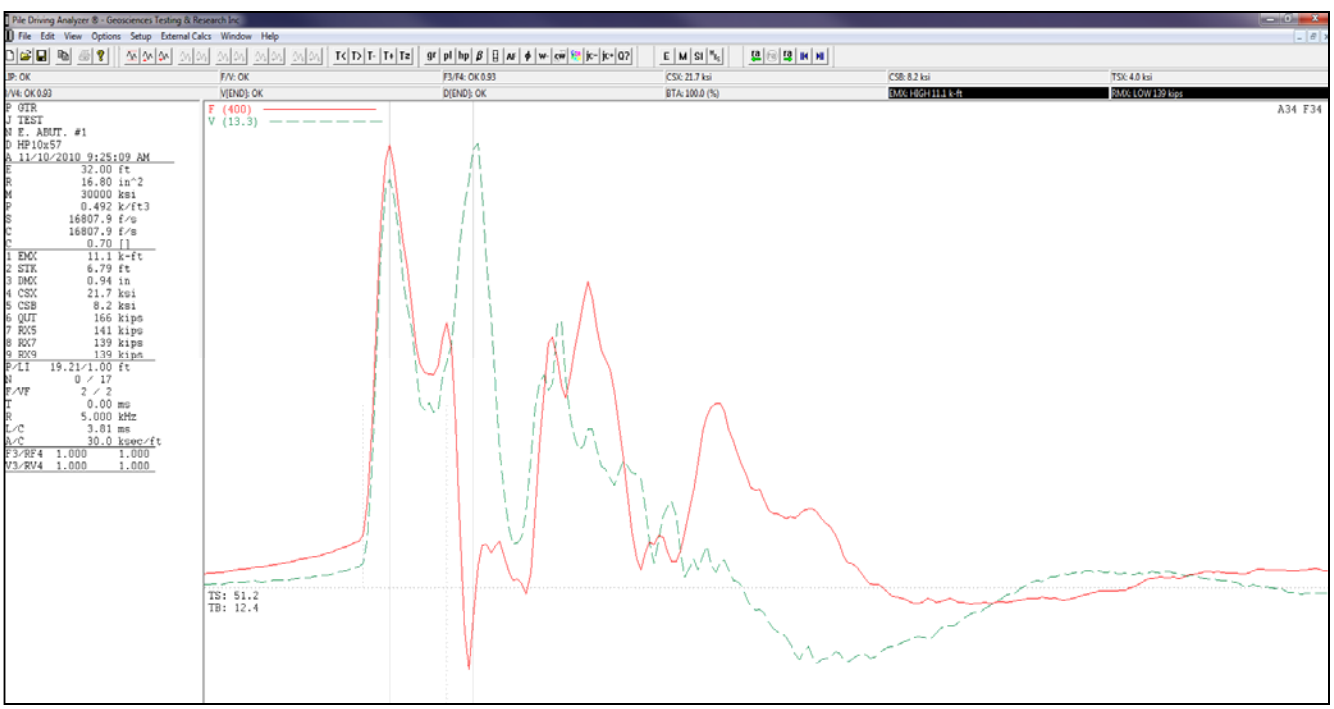


Figure 1. Data collection during pile driving in the (PDI - PDA®-Win Program).

Theory

When a ram strikes the pile head, it initiates a large strain wave that propagates down the pile as illustrated in Figure 2. External soil resistance or changes in the pile's impedance (due to variations in the pile's material or geometry) causes reflection waves that are recorded by the instrumentation. Knowing the material properties and pile geometry at the point of measurement, the strain can be converted to force, while the acceleration is integrated with time to produce velocity.

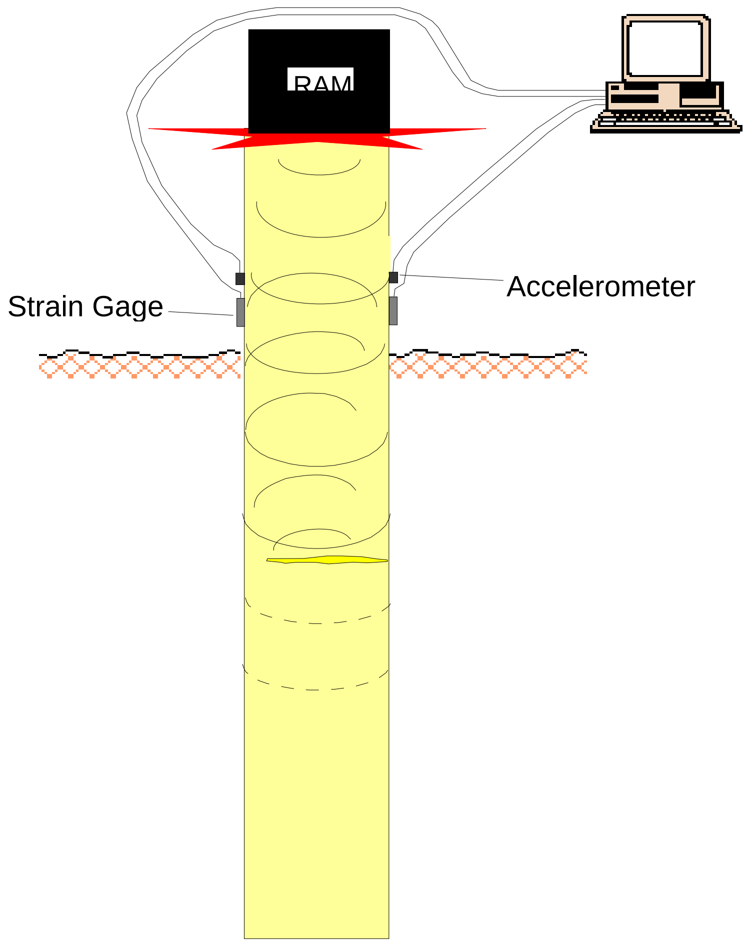


Figure 2. Pile instrumentation and hammer impact.

As long as there is no change in the pile impedance and there are no external forces (i.e. friction), the force and velocity are proportional (equal). Reflections at the tip can be explained by two classical boundary conditions. Free end conditions (analogous to easy driving through soft clay) require zero force and no velocity restrictions at the tip, resulting in a compression wave returning as a tension wave and an increase in velocity (theoretically doubling). Figure 3 graphically presents a typical reflection from a pipe pile during penetration into soft clay. Fixed end conditions (analogous to hard driving into bedrock) require zero velocity and no force restrictions at the tip, resulting in a compression wave being reflected with a greater magnitude than the incident wave (theoretically doubling) and the tip velocity at theoretically zero. Figure 4 graphically presents a typical reflection from an H-pile driven to bedrock. The time the wave takes to travel down to the tip and reflect back to the transducers is twice the pile length divided by the wave speed of the pile material (2L/C).

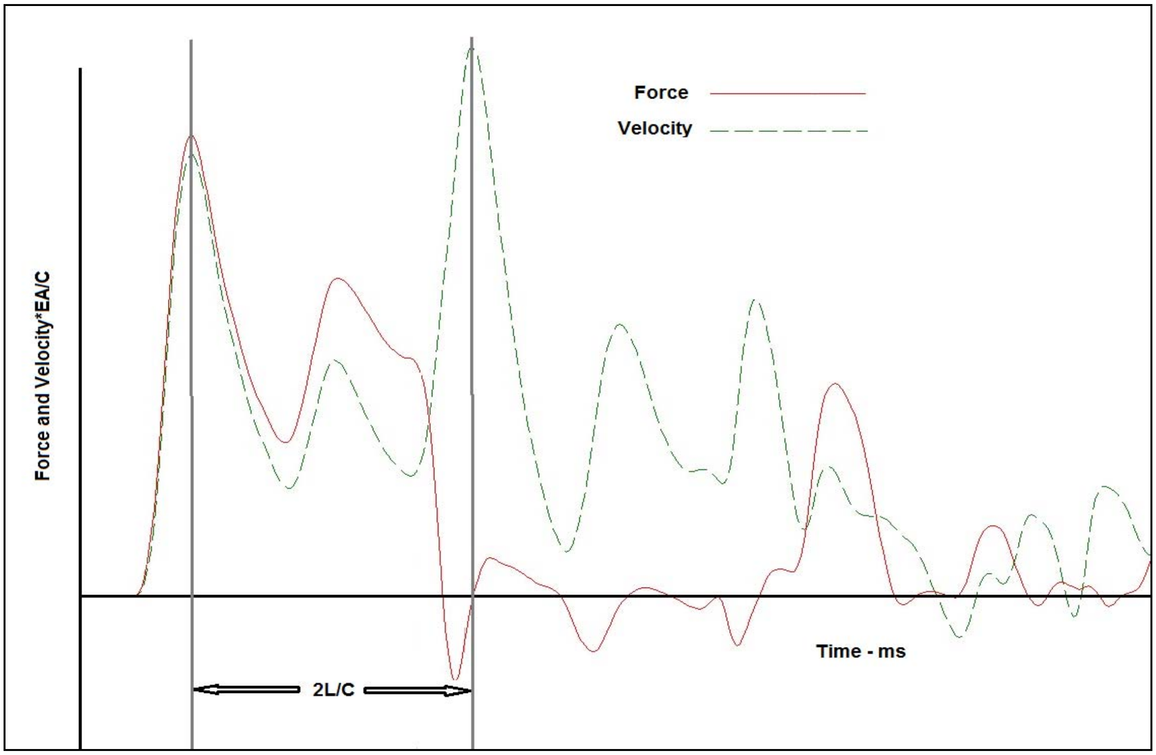


Figure 3. Typical Force and Velocity traces for a pipe pile driven into soft clay
(high velocity and low force at tip - 2L/C).

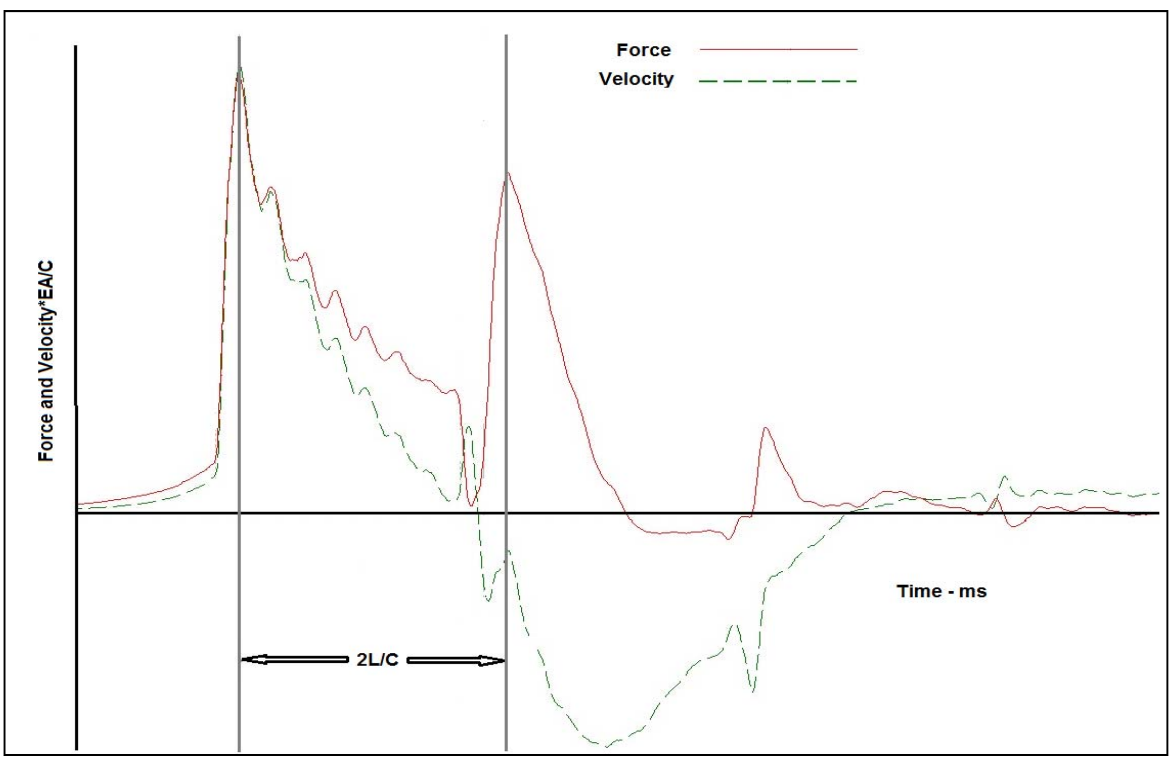


Figure 4. Typical Force and Velocity traces for an H-pile driven into bedrock
(high force and low velocity at tip - 2L/C).

If a pile contains a defect or is damaged (e.g. reduction in impedance) during driving, the wave reflecting from the zone of decreased impedance will show a reduction in the force and increase in the velocity (somewhat comparable to "free end conditions"). These reflections would arrive to the measuring transducers before the expected reflections associated with the pile tip as the damaged zone is at a point along the pile between the transducer location and pile tip. The detection of damage during driving is usually easily identifiable and typically associated with cracking of concrete piles or splice breakage.

Dynamic Testing Summary Output

After data collection, the most pertinent output quantities from the dynamic pile testing can be summarized in a graphical manner. The data can be also presented in tabular format, averaging the results based on penetration depth or blow number as specified by the user. Figure 5 shows typical graphical output. Each of the three plots presents two quantities sharing the vertical (penetration) axis.

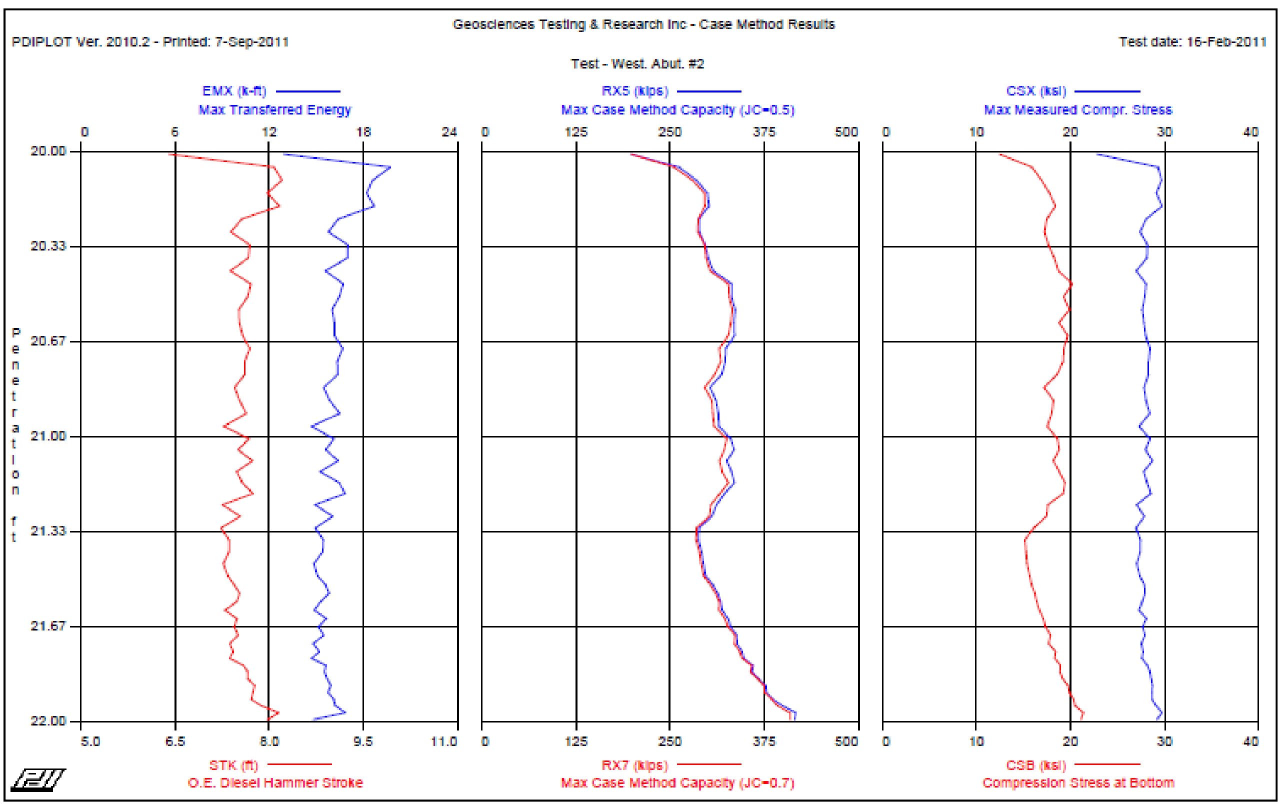


Figure 5. Typical Dynamic Testing summary Output (PDI Plot® Program)

Signal Matching Analyses

Signal matching using the dynamic testing data can be performed to predict the static pile capacity. Programs such as CAPWAP® (developed by Pile Dynamics, Inc.) or TEPWAP/PWAP (developed by GTR) are numerical analyses used to solve the one dimensional wave equation using the measured force and velocity. E.A Smith (1960) suggested modeling the hammer-pile-soil system for use in the wave equation by a series of masses, springs and dashpots as shown in Figure 6. The signal matching programs determine the best match between measured and calculated pile top forces and replace the hammer input with the measured force and velocity. The pile is separated into many small segments, often 1 meter in length. The velocity record obtained from the dynamic pile testing transducers is used as input to the top pile segment. The resistance, damping, and quake are the primary soil parameters assigned by the user to each pile segment below grade. The signal matching programs will calculate the displacement, velocity, and stresses (forces) for each pile segment based on the input velocity record and the user assigned soil parameters. These parameters are adjusted and modified in an iterative fashion until the best match is obtained between the force calculated for the pile top segment and the force measured at the pile top during testing. The user assigned soil parameters based on the best match represent the “actual soil conditions”, including the resistance (and therefore pile capacity). This capacity is based on the resistance at the time of the testing. Static load tests are typically conducted several days or weeks after driving. Therefore, restrike tests are recommended to be performed some time after driving to assess time dependent changes in pile capacity, such as setup or relaxation.

New PDA Appendix.docx

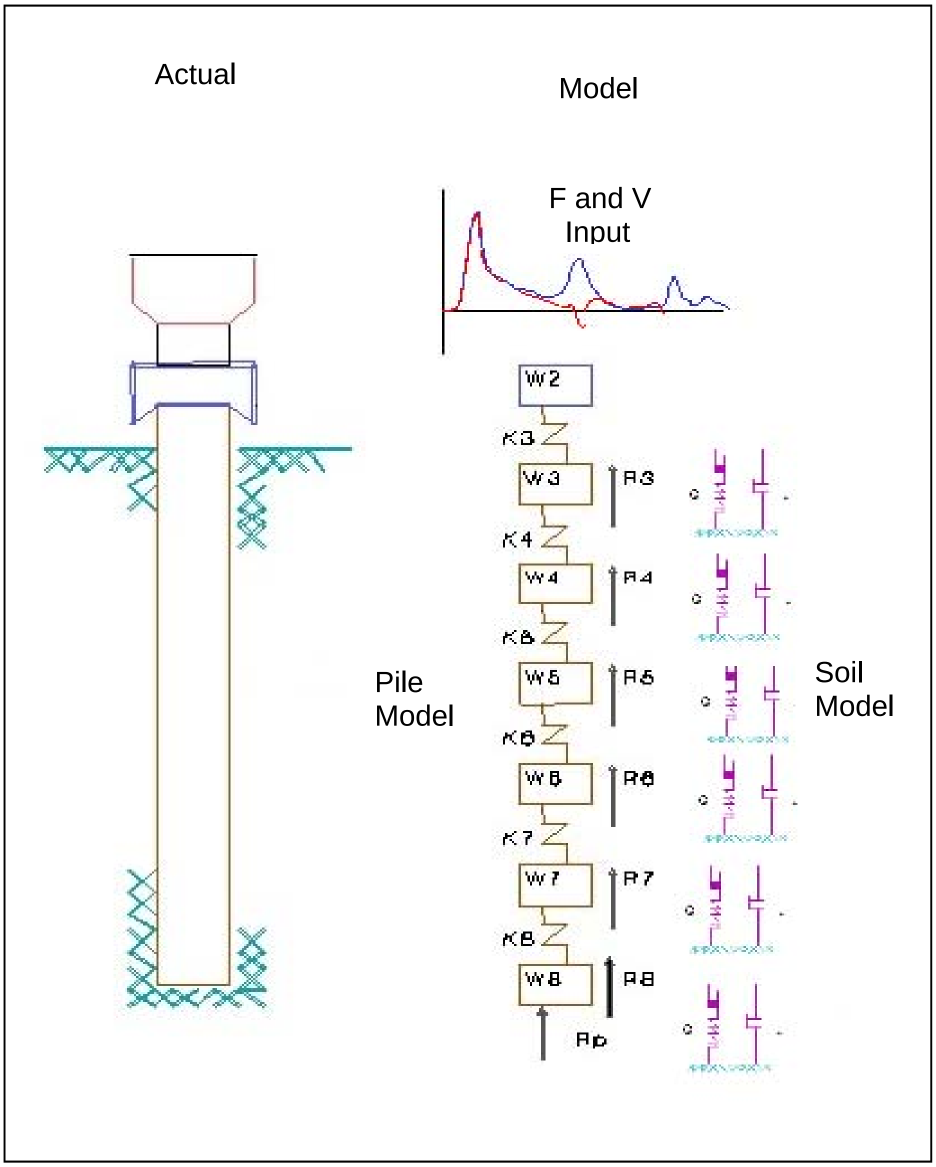


Figure 6. Signal Matching Model (i.e. CAPWAP® or TEPWAP/PWAP).

APPENDIX B
PDA VARIABLES

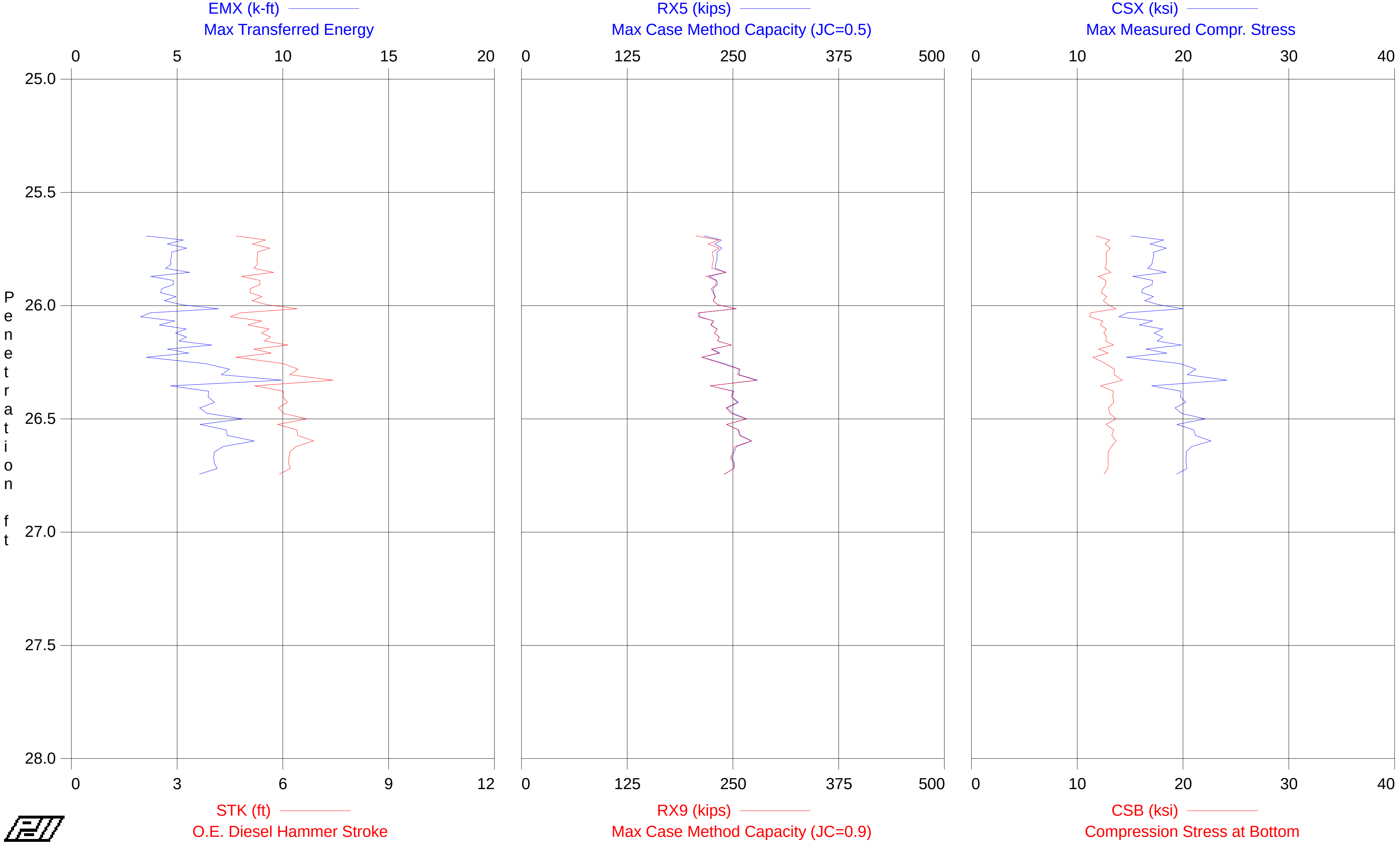
- **Plot 1 (left plot): Max Transferred Energy and Stroke**
- **Plot 2 (middle plot): Case Method Capacity (Jc=0.5 and Jc=0.7)**
- **Plot 3 (right plot): Max Measured Compression Stress at Pile Top and Max Estimated Compression Stress at the Pile Tip**

Geosciences Testing & Research Inc - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 8-Aug-2014

Test date: 4-Aug-2014

Brookfield Vtrans - ABUT1 #1 EOD



Brookfield Vtrans - ABUT1 #1 EOD
Test date: 4-Aug-2014
HP12x74

AR: 21.80 in^2
LE: 30.50 ft
WS: 16,810.0 f/s
SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
DMX: Maximum Displacement
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
QUT: Energy formula (DFN)
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	EMX	STK	DMX	CSX	CSB	QUT	RX5	RX7	RX9
	ft	bl/ft	k-ft	ft	in	ksi	ksi	kips	kips	kips	kips
3	25.69	112	3.9	4.84	0.25	15.8	12.1	365	219	214	210
5	25.71	112	5.3	5.50	0.30	18.1	13.0	343	234	229	228
7	25.72	112	4.3	5.01	0.27	16.5	12.5	346	226	220	218
9	25.74	112	5.4	5.62	0.31	18.4	13.1	332	237	236	235
11	25.76	112	5.2	5.52	0.30	18.0	13.0	330	234	232	231
13	25.78	112	4.3	5.00	0.26	16.4	12.4	364	228	224	222
15	25.79	112	4.7	5.25	0.28	17.1	12.8	361	231	229	227
17	25.81	112	5.3	5.58	0.31	18.2	13.1	335	234	232	230
19	25.83	112	4.3	5.07	0.26	16.3	12.4	361	228	225	223
21	25.85	112	6.5	6.22	0.35	19.9	13.7	330	256	256	256
23	25.87	112	3.8	4.85	0.25	15.3	12.0	343	221	220	218
25	25.88	112	4.1	5.00	0.26	16.0	12.1	354	226	226	226
27	25.90	112	5.7	5.77	0.33	18.5	13.2	334	240	239	238
29	25.92	112	4.0	4.93	0.26	15.6	12.2	351	224	223	222
31	25.94	112	4.3	5.12	0.27	16.3	12.3	344	228	227	227
33	25.96	112	5.8	5.81	0.33	18.5	13.3	336	234	234	234
35	25.97	112	4.6	5.23	0.28	16.8	12.6	347	228	228	228
37	25.99	112	4.6	5.22	0.28	16.7	12.7	332	229	229	229
39	26.01	112	4.8	5.34	0.29	17.0	12.6	313	229	228	227
41	26.03	112	5.2	5.55	0.32	17.7	12.7	308	226	226	226
43	26.04	112	2.4	4.03	0.19	11.9	10.2	298	198	196	196
45	26.06	112	5.8	5.82	0.33	18.6	12.9	314	233	233	233
47	26.08	112	3.9	4.88	0.26	15.3	11.9	327	222	222	221
49	26.10	112	5.7	5.75	0.33	18.5	12.9	319	234	234	234
51	26.12	112	4.5	5.19	0.28	16.6	12.3	335	224	224	224
53	26.13	112	6.5	6.20	0.35	19.8	13.5	323	246	246	246
55	26.15	112	4.3	5.11	0.27	16.2	12.1	331	222	222	222
57	26.17	112	8.5	7.05	0.42	22.7	14.4	331	272	272	272
59	26.19	112	5.9	5.84	0.33	19.0	13.0	320	239	237	237
61	26.21	112	5.8	5.82	0.33	19.0	13.3	322	241	240	240
63	26.22	112	3.2	4.52	0.23	14.0	11.2	332	212	212	211
		Average	4.8	5.31	0.29	17.0	12.5	335	229	228	227
		Std. Dev.	1.1	0.57	0.04	1.9	0.8	18	13	13	13
		Maximum	9.1	7.48	0.44	23.1	14.7	375	280	279	278
		Minimum	2.3	4.03	0.19	11.8	9.9	288	195	193	192

Total number of blows analyzed: 62

Time Summary

Drive 13 minutes 12 seconds 10:10:57 AM - 10:24:09 AM (8/4/2014) BN 1 - 107

Brookfield Vtrans - ABUT1 #1 EOD
Test date: 4-Aug-2014

HP12x74

AR: 21.80 in^2
LE: 30.50 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
DMX: Maximum Displacement
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom

QUT: Energy formula (DFN)
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	EMX	STK	DMX	CSX	CSB	QUT	RX5	RX7	RX9
	ft	bl/ft	k-ft	ft	in	ksi	ksi	kips	kips	kips	kips
66	26.25	112	6.6	6.15	0.37	20.2	12.7	295	242	241	241
68	26.27	82	8.2	6.72	0.42	22.1	13.7	313	267	267	267
70	26.30	82	6.1	5.87	0.34	19.4	13.1	313	244	242	242
72	26.32	82	12.4	8.45	0.54	27.1	15.2	346	299	297	296
74	26.35	82	4.3	5.03	0.28	16.4	12.0	311	216	216	216
76	26.37	82	6.5	6.00	0.36	19.8	13.5	329	253	252	252
78	26.40	82	7.5	6.43	0.40	21.2	13.8	317	261	261	261
80	26.42	82	6.1	5.83	0.34	19.3	13.3	315	249	247	246
82	26.45	82	7.0	6.28	0.38	20.6	13.4	320	254	252	252
84	26.47	82	6.6	6.08	0.36	20.0	13.2	315	252	249	248
86	26.49	82	7.1	6.23	0.39	20.6	13.2	299	256	256	256
88	26.52	82	5.8	5.71	0.34	18.9	12.4	300	236	236	236
90	26.54	82	5.7	5.66	0.33	18.6	12.8	301	240	239	238
92	26.57	82	7.3	6.43	0.39	21.4	13.2	318	255	255	254
94	26.59	82	8.6	6.81	0.44	22.5	13.6	319	271	271	271
96	26.62	82	6.8	6.21	0.38	20.3	13.0	304	247	245	243
98	26.64	82	6.5	6.11	0.37	20.0	12.9	287	246	243	243
100	26.66	82	6.8	6.21	0.38	20.3	13.0	296	249	247	247
102	26.69	82	6.0	5.85	0.35	19.3	12.7	283	240	238	238
104	26.71	82	6.8	6.18	0.38	20.3	12.8	291	250	250	250
106	26.74	82	6.5	6.07	0.37	20.0	12.7	292	247	247	247
		Average	6.9	6.22	0.38	20.4	13.2	310	252	252	251
		Std. Dev.	1.3	0.56	0.04	1.8	0.6	13	15	15	15
		Maximum	12.4	8.45	0.54	27.1	15.2	346	299	297	296
		Minimum	4.3	5.03	0.28	16.4	12.0	283	216	216	216

Total number of blows analyzed: 42

Time Summary

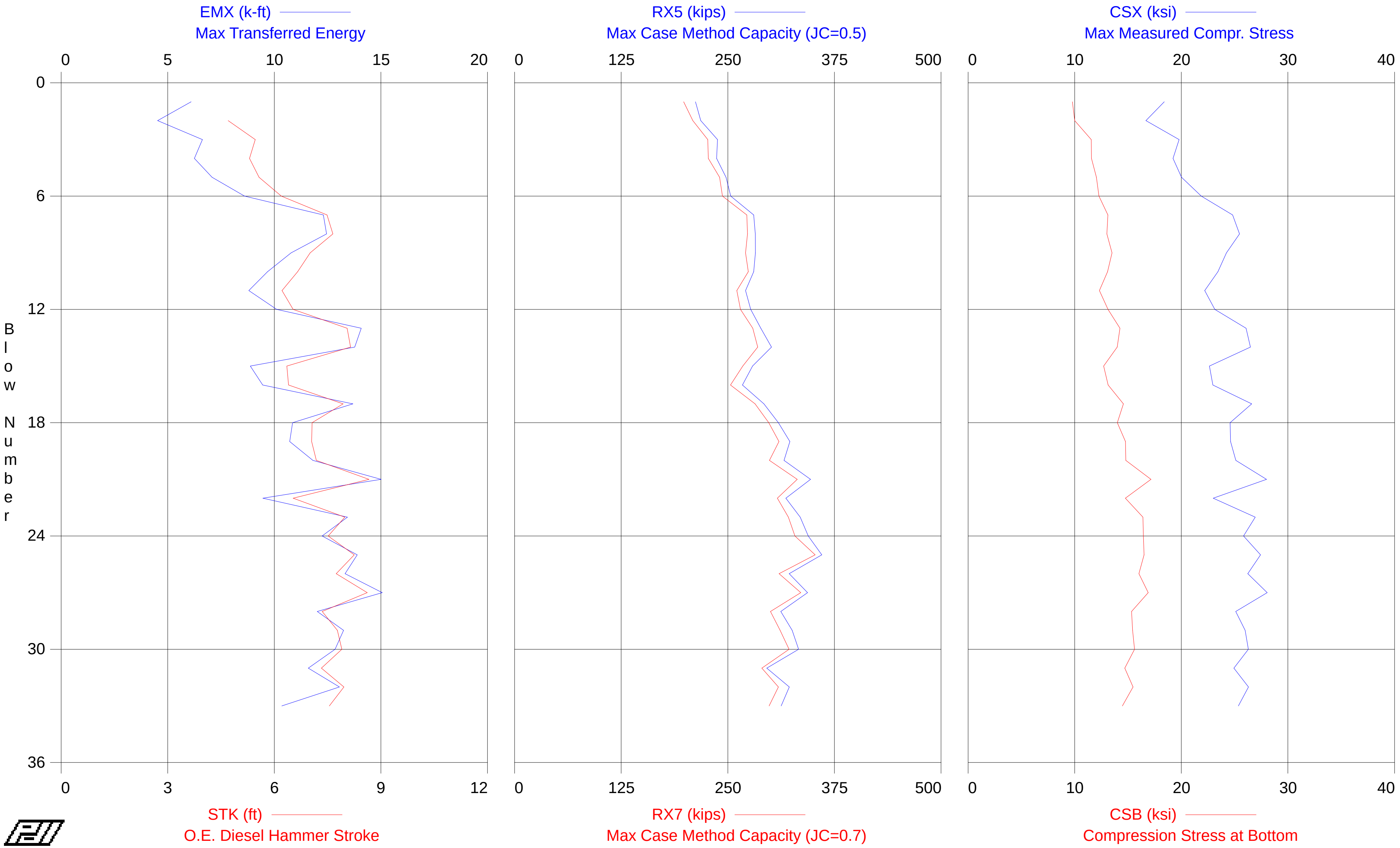
Drive 13 minutes 12 seconds 10:10:57 AM - 10:24:09 AM (8/4/2014) BN 1 - 107

Geosciences Testing & Research Inc - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 8-Aug-2014

Test date: 6-Aug-2014

Brookfield - ABUT1 #1 BOR



Brookfield - ABUT1 #1 BOR
Test date: 6-Aug-2014

HP12x74

AR: 21.80 in^2
LE: 30.50 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
DMX: Maximum Displacement
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom

QUT: Energy formula (DFN)
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	EMX	STK	DMX	CSX	CSB	QUT	RX5	RX7	RX9
	ft	k-ft	ft	in	ksi	ksi	kips	kips	kips	kips
1	26.50	6.1	0.00	0.34	18.4	9.8	275	212	198	192
3	26.50	6.6	5.46	0.34	19.8	11.5	326	238	226	218
5	26.50	7.1	5.57	0.35	20.0	12.0	337	248	240	233
7	26.50	12.3	7.48	0.53	24.8	13.1	343	280	272	267
9	26.50	10.8	7.01	0.48	24.2	13.5	350	282	271	262
11	26.50	8.8	6.22	0.42	22.2	12.3	353	271	261	252
13	26.50	14.1	8.05	0.58	26.1	14.2	345	289	279	276
15	26.50	8.9	6.35	0.41	22.6	12.7	361	279	268	260
17	26.50	13.7	7.94	0.56	26.6	14.6	356	292	282	279
19	26.50	10.7	7.05	0.45	24.6	14.8	376	323	310	297
21	26.50	15.0	8.67	0.57	28.0	17.2	400	347	331	322
23	26.50	13.4	7.98	0.53	26.9	16.4	420	335	321	316
25	26.50	13.9	8.25	0.55	27.4	16.5	403	360	352	345
27	26.50	15.1	8.62	0.59	28.1	16.9	421	344	336	334
29	26.50	13.2	7.78	0.56	26.0	15.4	370	326	311	309
31	26.50	11.6	7.33	0.51	24.9	14.7	353	296	290	290
33	26.50	10.4	7.55	0.48	25.4	14.5	368	313	298	284
	Average	11.0	7.13	0.48	24.2	14.0	362	295	283	277
	Std. Dev.	2.7	0.97	0.08	2.8	1.9	31	37	37	37
	Maximum	15.1	8.67	0.59	28.1	17.2	421	360	352	345
	Minimum	4.5	4.70	0.25	16.7	9.8	275	212	198	192

Total number of blows analyzed: 33

Time Summary

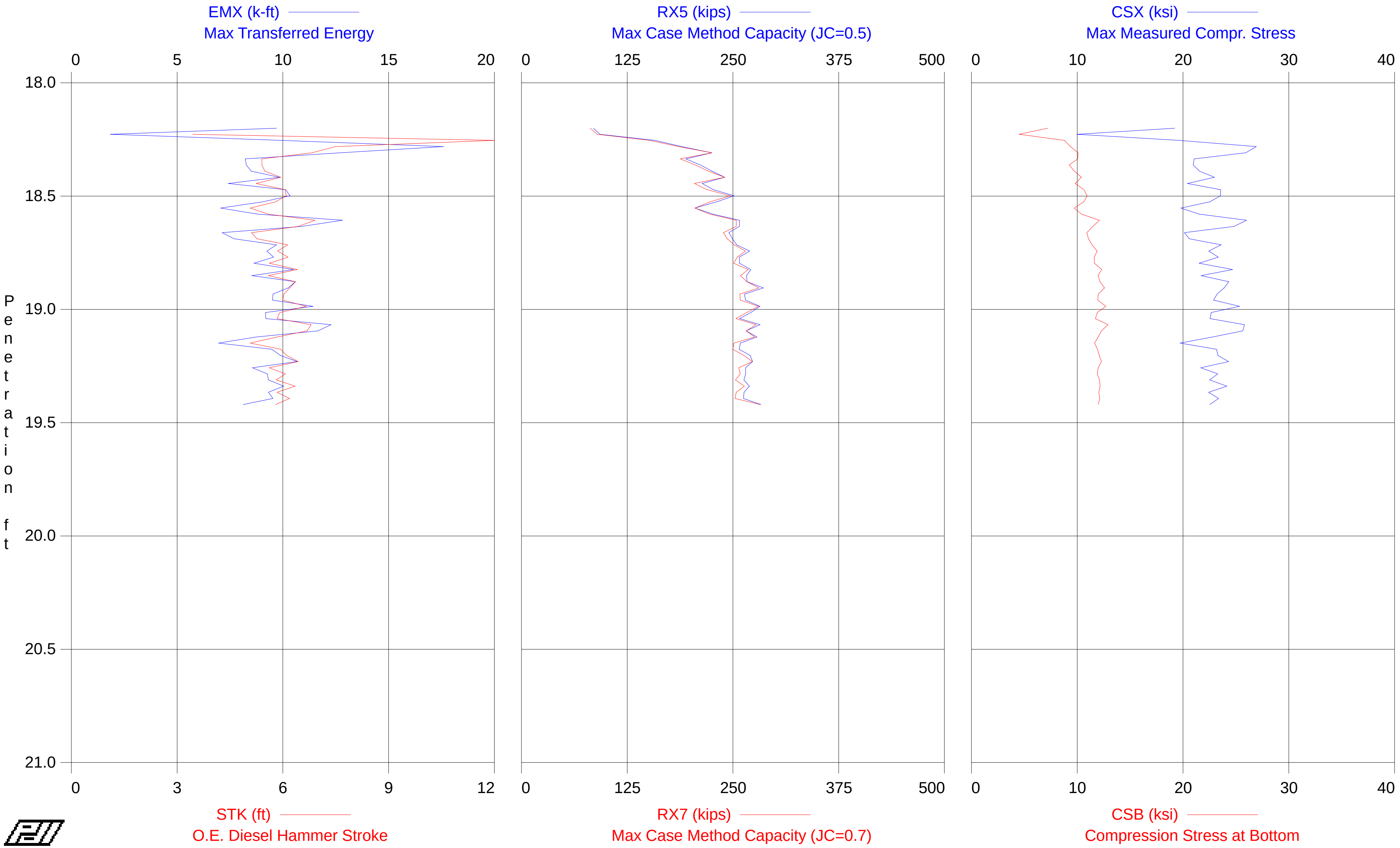
Drive 43 seconds 7:53:25 AM - 7:54:08 AM (8/6/2014) BN 1 - 33

Geosciences Testing & Research Inc - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 8-Aug-2014

Test date: 4-Aug-2014

Brookfield Vtrans - ABUT1 #2 EOD



Brookfield Vtrans - ABUT1 #2 EOD
Test date: 4-Aug-2014

HP12x74

AR: 21.80 in^2
LE: 37.50 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
DMX: Maximum Displacement
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom

QUT: Energy formula (DFN)
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	BLC	EMX	STK	DMX	CSX	CSB	QUT	RX5	RX7	RX9
	ft	bl/ft	k-ft	ft	in	ksi	ksi	kips	kips	kips	kips
21	18.74	37	9.2	5.85	0.51	22.4	11.9	263	270	265	260
22	18.77	37	9.6	6.15	0.52	23.3	11.6	289	258	255	255
23	18.80	37	8.6	5.62	0.50	21.5	11.6	234	258	251	244
24	18.82	37	10.5	6.41	0.55	24.7	12.3	291	271	268	265
25	18.85	37	8.5	5.59	0.48	21.7	12.0	262	266	259	252
26	18.88	37	10.6	6.36	0.55	24.3	12.2	294	267	266	266
27	18.90	37	10.2	6.20	0.54	23.9	12.6	280	286	281	276
28	18.93	37	9.5	6.03	0.51	23.2	12.0	293	264	258	253
29	18.96	37	9.5	5.99	0.51	22.9	11.9	288	265	259	254
30	18.99	37	11.4	6.67	0.58	25.3	12.7	287	282	280	278
31	19.01	37	9.2	5.91	0.50	22.7	11.9	279	271	266	262
32	19.04	37	9.2	5.83	0.51	22.5	11.7	285	258	254	249
33	19.07	37	12.3	6.80	0.62	25.8	12.9	271	282	278	273
34	19.09	37	11.7	6.69	0.58	25.6	12.3	290	266	266	266
35	19.12	37	8.8	5.84	0.49	22.8	12.0	291	278	276	273
36	19.15	37	7.0	5.07	0.42	19.7	11.6	276	259	251	244
37	19.18	37	9.5	5.94	0.51	23.2	11.9	273	257	250	248
38	19.20	37	9.9	6.11	0.52	23.3	12.1	284	270	263	256
39	19.23	37	10.7	6.43	0.56	24.3	12.3	277	273	273	273
40	19.26	37	8.6	5.62	0.48	21.7	12.0	268	265	257	249
41	19.28	37	9.3	6.08	0.50	23.3	11.9	291	265	259	255
42	19.31	37	9.3	5.81	0.51	22.5	12.1	265	263	253	247
43	19.34	37	10.0	6.35	0.53	24.1	12.2	290	269	264	264
44	19.37	37	9.3	5.83	0.50	22.4	12.0	264	263	254	249
45	19.39	37	9.5	6.19	0.51	23.4	12.1	274	262	253	250
46	19.42	37	8.1	5.79	0.47	22.5	12.0	267	283	282	281
		Average	9.6	6.05	0.52	23.2	12.1	278	268	263	259
		Std. Dev.	1.1	0.38	0.04	1.3	0.3	14	8	10	11
		Maximum	12.3	6.80	0.62	25.8	12.9	294	286	282	281
		Minimum	7.0	5.07	0.42	19.7	11.6	234	257	250	244

Total number of blows analyzed: 26

Time Summary

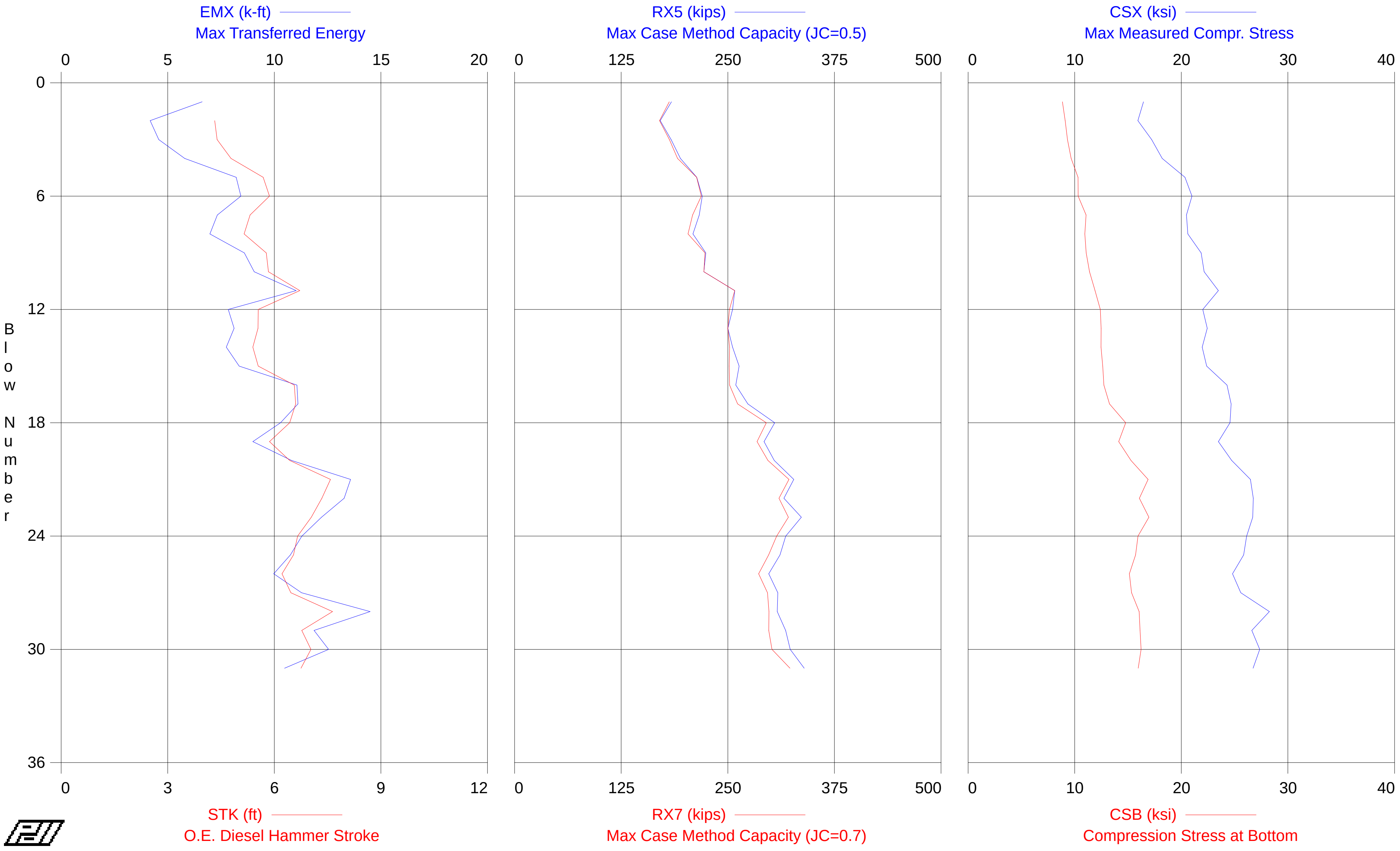
Drive 57 seconds 10:54:23 AM - 10:55:20 AM (8/4/2014) BN 1 - 46

Geosciences Testing & Research Inc - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 8-Aug-2014

Test date: 6-Aug-2014

Brookfield - ABUT1 #2 BOR



Brookfield - ABUT1 #2 BOR
Test date: 6-Aug-2014

HP12x74

AR: 21.80 in^2
LE: 23.50 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
DMX: Maximum Displacement
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom

QUT: Energy formula (DFN)
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
RX9: Max Case Method Capacity (JC=0.9)

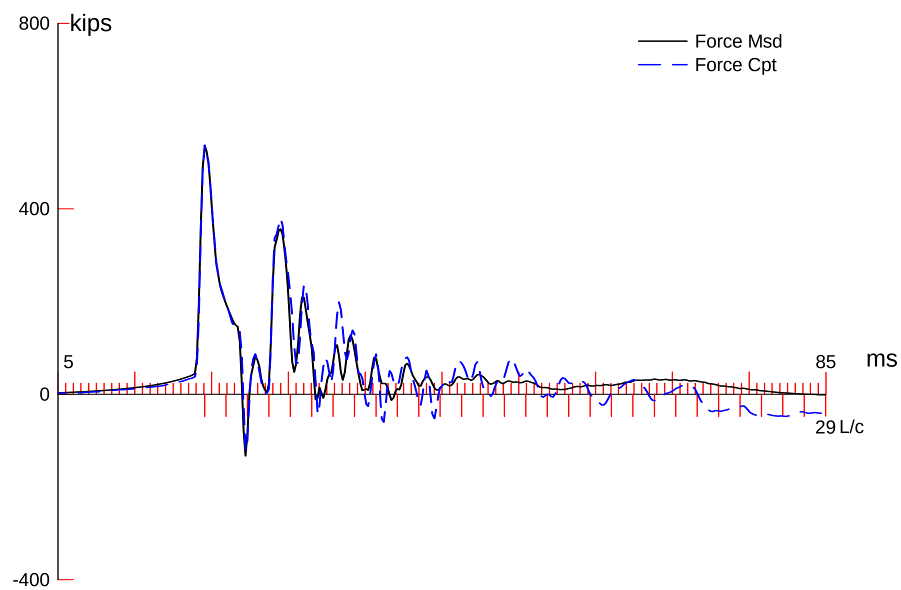
BL#	depth	EMX	STK	DMX	CSX	CSB	QUT	RX5	RX7	RX9
	ft	k-ft	ft	in	ksi	ksi	kips	kips	kips	kips
1	19.20	6.6	0.00	0.42	16.5	8.9	237	184	181	181
3	19.20	4.6	4.39	0.28	17.2	9.3	320	184	181	180
5	19.20	8.2	5.69	0.46	20.3	10.3	261	214	213	213
7	19.20	7.3	5.32	0.41	20.5	11.1	274	217	209	205
9	19.20	8.6	5.78	0.46	21.9	11.1	276	224	223	222
11	19.20	11.0	6.72	0.54	23.5	11.9	299	258	258	258
13	19.20	8.1	5.54	0.41	22.4	12.5	322	250	250	250
15	19.20	8.4	5.55	0.41	22.4	12.6	315	263	252	252
17	19.20	11.1	6.60	0.51	24.7	13.3	309	273	261	257
19	19.20	9.0	5.86	0.41	23.5	14.1	375	292	284	276
21	19.20	13.6	7.58	0.54	26.5	16.9	387	327	322	322
23	19.20	12.2	7.04	0.50	26.7	17.0	395	336	321	311
25	19.20	10.8	6.54	0.45	25.8	15.7	395	311	298	289
27	19.20	11.3	6.47	0.48	25.6	15.3	369	309	297	293
29	19.20	11.9	6.77	0.49	26.6	16.1	383	318	298	295
31	19.20	10.5	6.75	0.45	26.7	16.0	399	340	323	308
	Average	9.6	6.13	0.45	23.2	13.2	329	266	259	256
	Std. Dev.	2.5	0.85	0.07	3.3	2.5	50	50	46	44
	Maximum	14.5	7.64	0.58	28.3	17.0	399	340	323	322
	Minimum	4.2	4.32	0.28	15.9	8.9	237	171	170	169

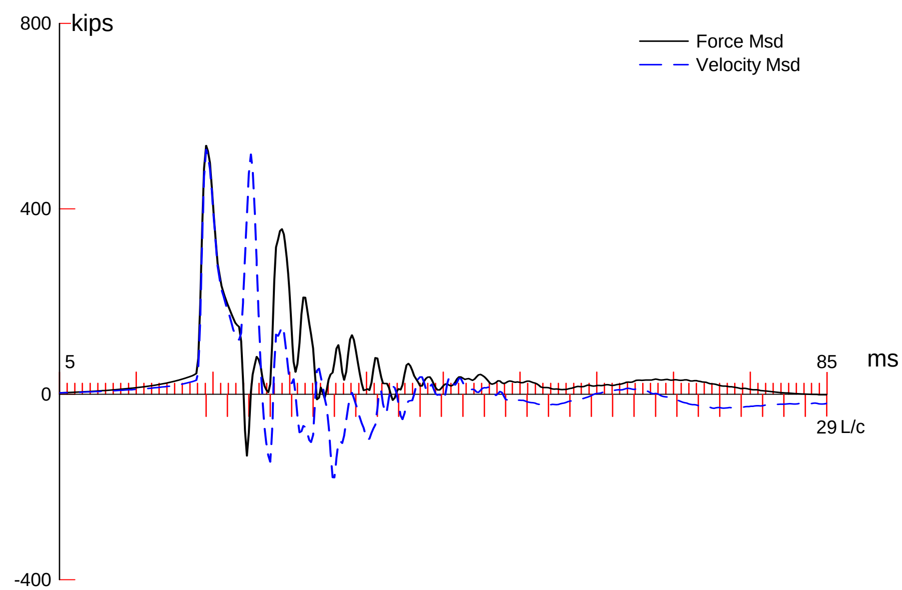
Total number of blows analyzed: 31

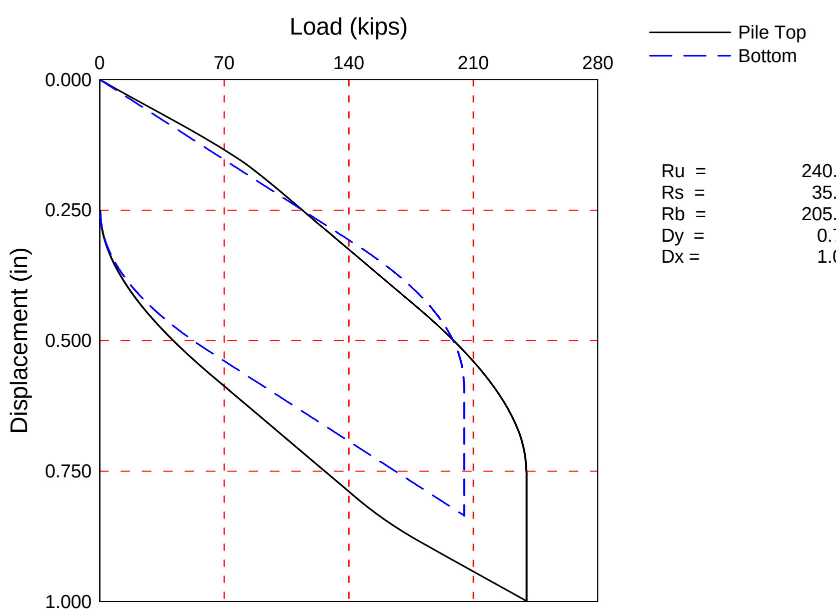
Time Summary

Drive 37 seconds 8:10:55 AM - 8:11:32 AM (8/6/2014) BN 1 - 31

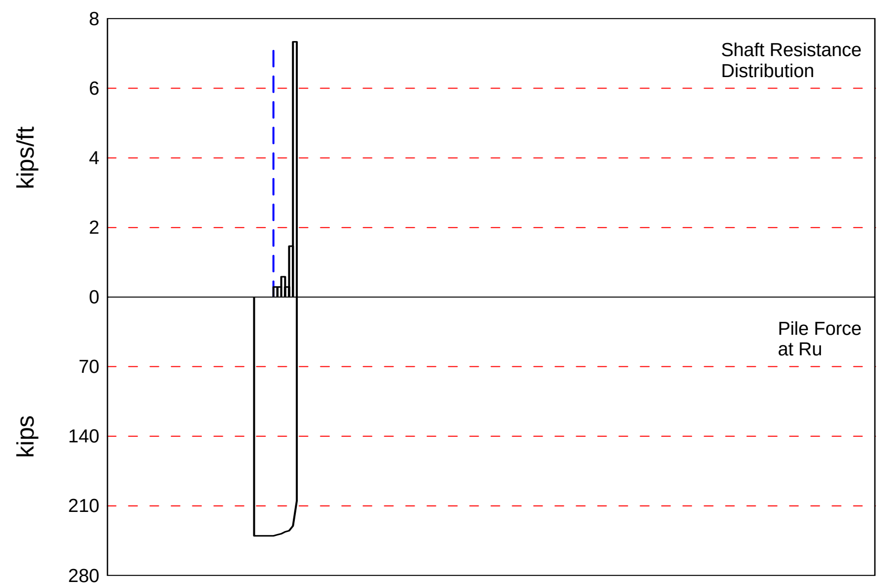
APPENDIX C
CAPWAP RESULTS







Ru =	240.0	kips
Rs =	35.0	kips
Rb =	205.0	kips
Dy =	0.75	in
Dx =	1.00	in



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 240.0; along Shaft 35.0; at Toe 205.0 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Smith Damping Factor s/ft
				240.0				
1	20.5	2.5	1.0	239.0	1.0	0.41	0.10	0.120
2	23.9	5.9	1.0	238.0	2.0	0.29	0.07	0.120
3	27.3	9.3	2.0	236.0	4.0	0.59	0.15	0.120
4	30.7	12.7	1.0	235.0	5.0	0.29	0.07	0.120
5	34.1	16.1	5.0	230.0	10.0	1.47	0.37	0.120
6	37.5	19.5	25.0	205.0	35.0	7.33	1.83	0.120
Avg. Shaft			5.8			1.79	0.45	0.120
Toe			205.0				205.00	0.050

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.100	0.450
Case Damping Factor		0.108	0.263
Damping Type			Smith
Unloading Quake	(% of loading quake)	20	20
Reloading Level	(% of Ru)	100	100
Soil Plug Weight	(kips)		0.00

CAPWAP match quality = 4.21 (Force Match) ; RSA = 0
Observed: final set = 0.250 in; blow count = 48 b/ft
Computed: final set = 0.283 in; blow count = 42 b/ft

max. Top Comp. Stress = 24.6 ksi (T= 20.5 ms, max= 1.000 x Top)
max. Comp. Stress = 24.6 ksi (Z= 3.4 ft, T= 20.5 ms)
max. Tens. Stress = -7.27 ksi (Z= 10.2 ft, T= 24.3 ms)
max. Energy (EMX) = 12.3 kip-ft; max. Measured Top Displ. (DMX)= 0.66 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.4	537.1	-122.1	24.6	-5.60	12.31	13.6	0.652
2	6.8	536.1	-154.0	24.6	-7.06	12.47	13.5	0.641
3	10.2	535.0	-158.6	24.5	-7.27	12.32	13.5	0.627
4	13.6	534.2	-140.9	24.5	-6.46	12.10	13.5	0.612
5	17.0	533.6	-112.0	24.5	-5.14	11.87	13.4	0.605
6	20.5	533.3	-86.4	24.5	-3.96	11.79	13.3	0.597
7	23.9	530.9	-59.2	24.3	-2.72	11.67	13.5	0.595
8	27.3	528.7	-50.1	24.2	-2.30	11.53	15.5	0.590
9	30.7	513.3	-73.8	23.5	-3.38	11.27	18.5	0.581
10	34.1	373.7	-55.2	17.1	-2.53	11.04	20.3	0.570
11	37.5	303.1	-34.1	13.9	-1.56	8.49	20.9	0.556
Absolute	3.4			24.6			(T =	20.5 ms)
	10.2				-7.27		(T =	24.3 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	261.9	175.3	88.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0
RX	306.5	293.0	289.3	286.6	283.8	281.1	278.3	275.6	272.9	270.1
RU	261.9	175.3	88.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0

RAU = 198.6 (kips); RA2 = 239.8 (kips)

Current CAPWAP Ru = 240.0 (kips); RMX requires J > 0.9;

Check with PDA-W; RA2 may be a better Case Method

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips
14.53	20.48	565.4	562.8	562.8	0.660	0.250	0.250	12.6	332.5

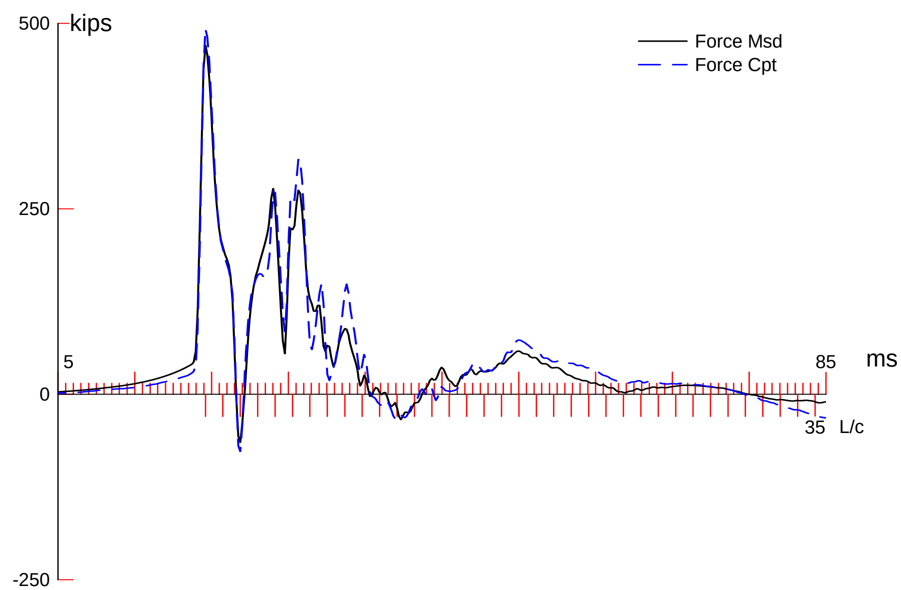
PILE PROFILE AND PILE MODEL

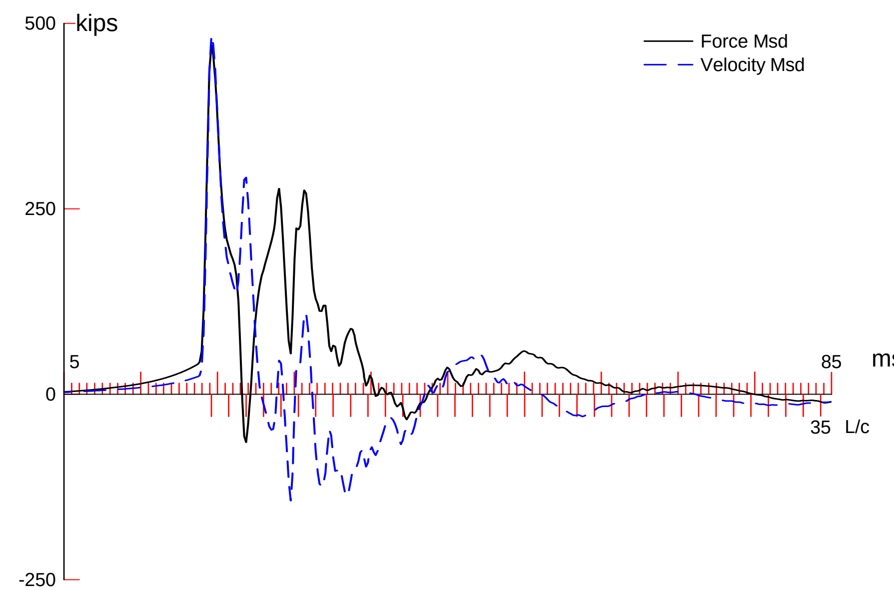
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	21.80	29999.9	492.000	4.000
37.50	21.80	29999.9	492.000	4.000

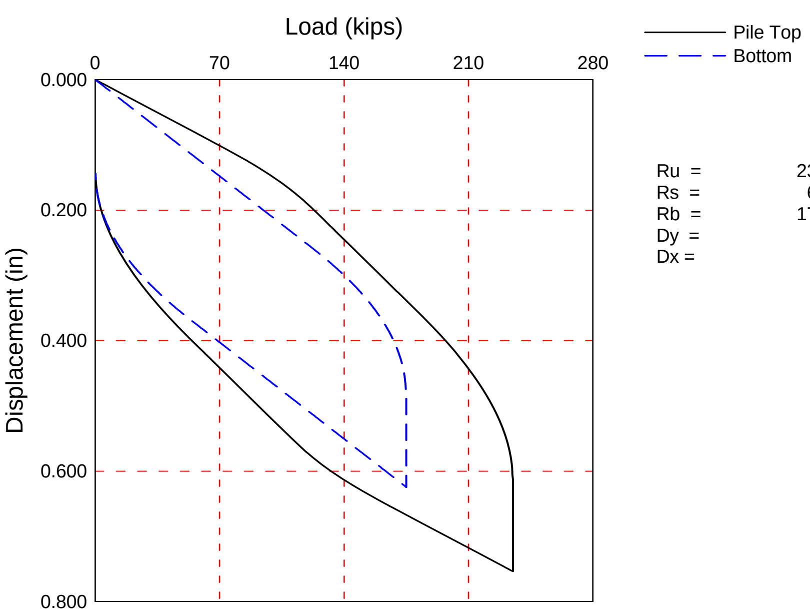
Toe Area 1.000 ft^2

Top Segment Length 3.41 ft, Top Impedance 38.92 kips/ft/s

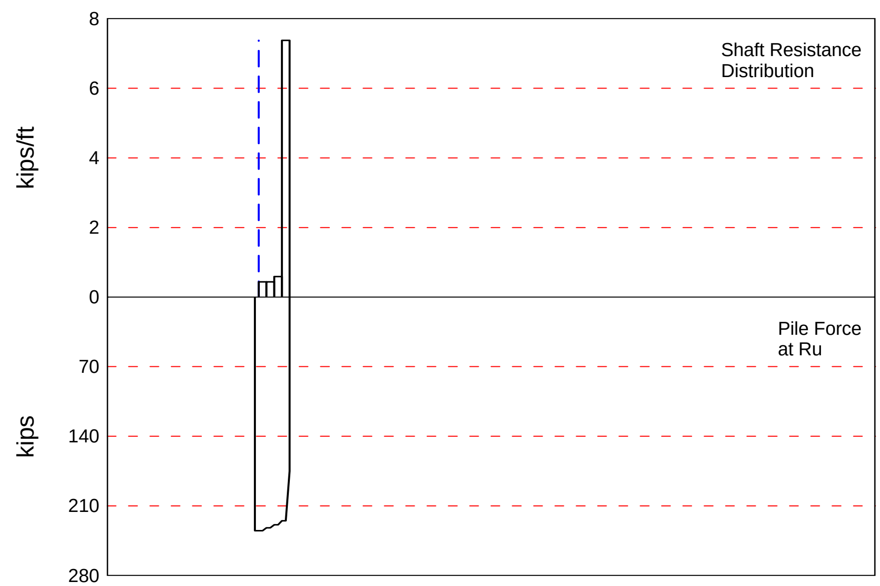
Pile Damping 2.0 %, Time Incr 0.203 ms, Wave Speed 16810.0 ft/s, 2L/c 4.5 ms







Ru =	235.0	kips
Rs =	60.0	kips
Rb =	175.0	kips
Dy =	0.61	in
Dx =	0.75	in



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 235.0; along Shaft 60.0; at Toe 175.0 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Smith Damping Factor s/ft
				235.0				
1	10.2	6.3	3.0	232.0	3.0	0.47	0.12	0.100
2	16.9	13.1	3.0	229.0	6.0	0.44	0.11	0.100
3	23.7	19.9	4.0	225.0	10.0	0.59	0.15	0.100
4	30.5	26.7	50.0	175.0	60.0	7.38	1.84	0.100
Avg. Shaft			15.0			2.25	0.56	0.100
Toe			175.0				175.00	0.120

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.100	0.370
Case Damping Factor		0.154	0.540
Damping Type			Smith
Unloading Quake	(% of loading quake)	50	50
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	90	
Resistance Gap (included in Toe Quake) (in)			0.020

CAPWAP match quality = 3.18 (Force Match) ; RSA = 0
Observed: final set = 0.143 in; blow count = 84 b/ft
Computed: final set = 0.172 in; blow count = 70 b/ft

max. Top Comp. Stress = 22.6 ksi (T= 20.6 ms, max= 1.003 x Top)
max. Comp. Stress = 22.6 ksi (Z= 10.2 ft, T= 21.2 ms)
max. Tens. Stress = -3.52 ksi (Z= 3.4 ft, T= 24.2 ms)
max. Energy (EMX) = 8.8 kip-ft; max. Measured Top Displ. (DMX)= 0.47 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.4	492.6	-76.8	22.6	-3.52	8.78	12.4	0.462
2	6.8	493.5	-65.3	22.6	-2.99	8.87	12.3	0.451
3	10.2	493.8	-65.2	22.6	-2.99	8.73	12.2	0.439
4	13.6	487.3	-62.2	22.3	-2.85	8.39	12.1	0.426
5	16.9	487.4	-61.4	22.4	-2.82	8.30	12.0	0.413
6	20.3	480.5	-57.7	22.0	-2.65	8.07	12.4	0.401
7	23.7	452.4	-57.3	20.7	-2.63	8.01	15.1	0.392
8	27.1	322.6	-53.3	14.8	-2.45	7.69	17.2	0.382
9	30.5	343.5	-53.1	15.8	-2.44	5.16	16.9	0.369
Absolute	10.2			22.6			(T =	21.2 ms)
	3.4				-3.52		(T =	24.2 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	299.1	231.2	163.2	95.2	27.2	0.0	0.0	0.0	0.0	0.0
RX	316.0	274.0	271.5	270.1	268.7	267.3	266.8	266.4	265.9	265.5
RU	299.1	231.2	163.2	95.2	27.2	0.0	0.0	0.0	0.0	0.0

RAU = 261.9 (kips); RA2 = 274.6 (kips)

Current CAPWAP Ru = 235.0 (kips); Corresponding J(RP)= 0.09;

RMX requires higher damping; see PDA-W

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips
12.82	20.56	499.0	480.0	480.0	0.472	0.143	0.143	8.9	346.8

PILE PROFILE AND PILE MODEL

Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	21.80	29999.9	492.000	4.000
30.50	21.80	29999.9	492.000	4.000

Toe Area 1.000 ft^2

Top Segment Length 3.39 ft, Top Impedance 38.92 kips/ft/s

Pile Damping 3.0 %, Time Incr 0.202 ms, Wave Speed 16810.0 ft/s, 2L/c 3.6 ms